Project 2
Simple file transfer using UDP socket interface

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Introduction:
The File Transfer Protocol (FTP) is a standard network protocol used for the transfer of computer files between a client and server on a computer network. FTP is built on a client-server model architecture using separate control and data connections between the client and the server. This project implements client-server model with Go-Back-N ARQ as it foundation. It replicates all the internal functioning of Go-Back-N ARQ such as acknowledgements, appropriate time-outs and retransmissions.

Specifications of the project:

- **RTO =** 400 ms
- **File size =** 1.2 MB

Go-back-N ARQ:
It is a specific instance of the automatic repeat request (ARQ) protocol, in which the sending process continues to send a number of frames specified by a window size even without receiving an acknowledgement (ACK) packet from the receiver. It is a special case of the general sliding window protocol with the transmit window size of N and receive window size of 1. It can transmit N frames to the peer before requiring an ACK.

Task 1: Effect of Window Size (N)
Setup:

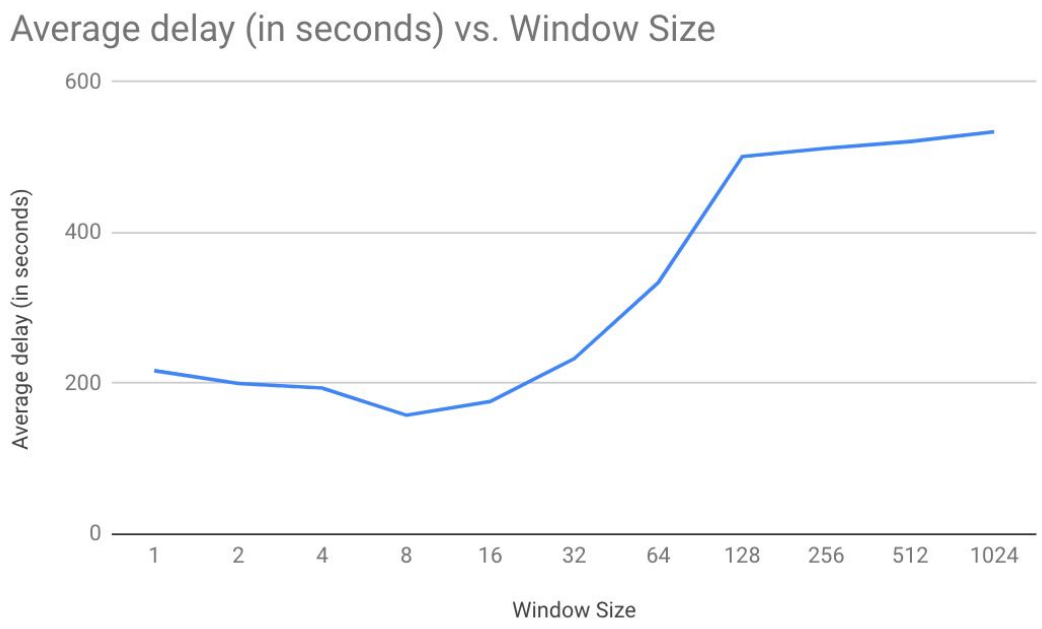
- MSS = 500 , p = 0.05, RTO = 400 ms, File size = 1.2 MB

Effect of windows size is analysed by varying only the value of Window Size (N) and keeping everything else constant.

Window Size (N)	Average delay (in seconds)
1	217
2	200
4	194
8	158
16	176
32	233
64	334

128	501
256	512
512	521
1024	534

Graph:



Observation: When N=1, average delay is the highest because client has to wait for every packet's acknowledgement before sending another packet. This is due to Stop-and-wait scenario, and therefore it wastes a lot of time and resources because typically clients and servers are capable of handling more than a single packet. As we increase N, we can see transfer time decreases as we are sending/receiving many packets per Round Trip Time. Also, towards the end we can see that average transfer time starts increasing again. This shows that beyond a certain value, if we still keep increasing N,delay will start increasing again as many packets are lost due to congestion.

Task 2: Effect of MSS

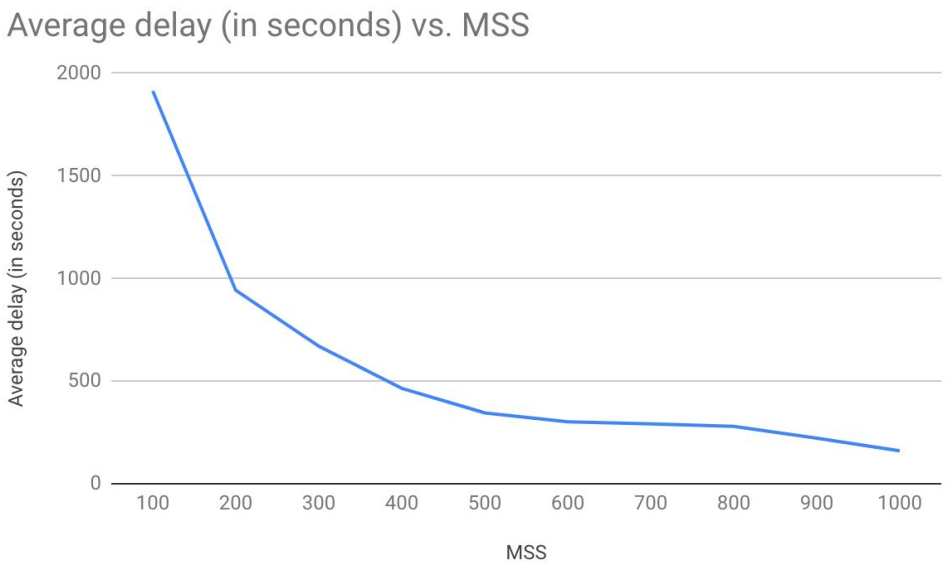
Setup:

- N=64, p = 0.05, RTO = 400 ms, File Size = 1.2 MB

The value of MSS is varied from 100 bytes to 1000 bytes in increments of 100 bytes.

MSS	Average Delay (in seconds)
100	1914
200	943
300	670
400	465
500	345
600	302
700	291
800	279
900	222
1000	160

Graph:



Observation: Referring to the chart, increasing maximum segment size reduces the time to transfer the file. The reason is that if N is fixed and MSS is increased, fewer packets have to be sent to transfer the file(i.e. more data sent per RTT)

Task 3: Effect of loss probability p

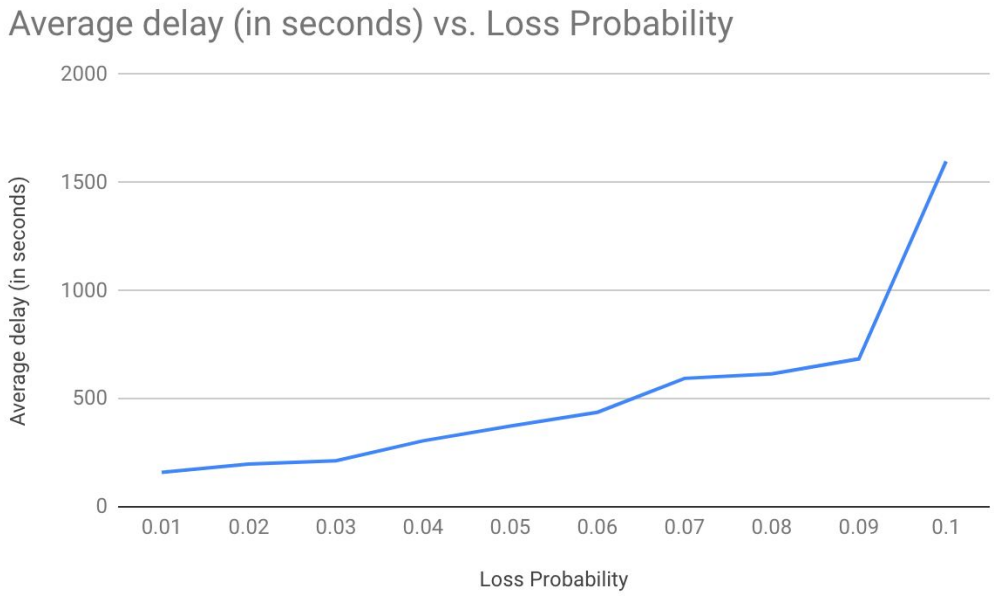
Setup:

- MSS = 500 bytes, N = 64

The loss probability is varied from 0.01 to 0.10 in increments of 0.01.

Loss probability p	Average Delay (in seconds)
0.01	159
0.02	198
0.03	213
0.04	305
0.05	373
0.06	437
0.07	594
0.08	615
0.09	684
0.10	1598

Graph:



Observation: As depicted by the graph, increasing loss probability increases the average time to transfer the file. Naturally more packets need to be retransmitted due to packet loss. For instance, if the loss probability is increased to 0.5 while keeping N & MSS the same, 500 per 1000 packets will need to be retransmitted per RTT which will massively increase the delay in the transfer.

Selective Repeat ARQ:

Selective Repeat is part of the automatic repeat-request (ARQ). With selective repeat, the sender sends a number of frames specified by a window size even without the need to wait for individual ACK from the receiver as in Go-Back-N ARQ. The receiver may selectively reject a single frame, which may be retransmitted alone; this contrasts with other forms of ARQ, which must send every frame from that point again. The receiver accepts out-of-order frames and buffers them. The sender individually retransmits frames that have timed out.

Task 1: Effect of Window Size (N)

Setup:

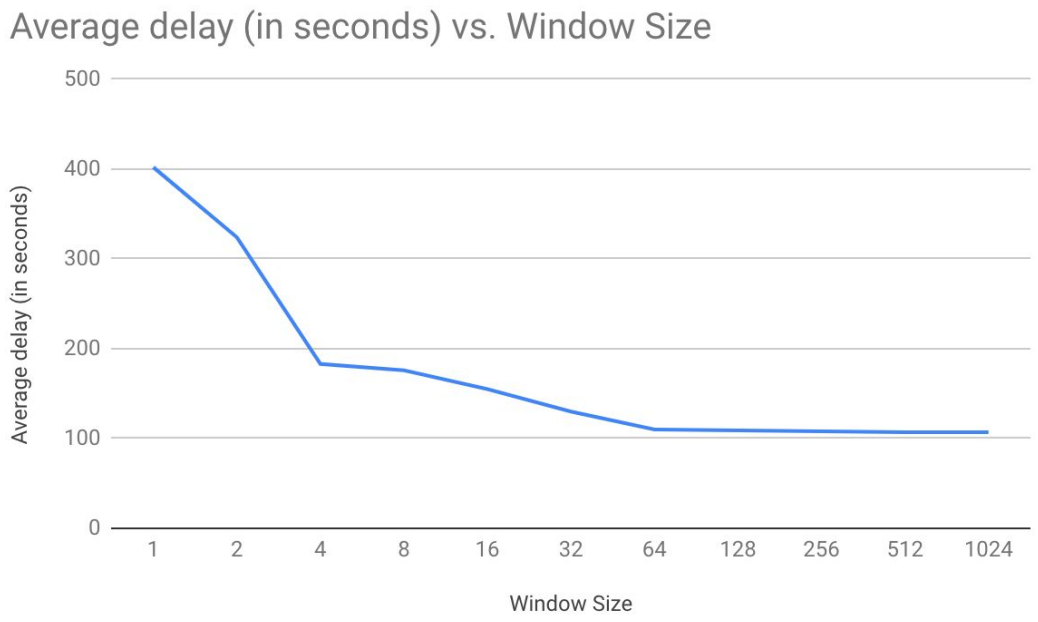
- MSS = 500 , p = 0.05, RTO = 400 ms, File size = 1.2 MB

Effect of windows size is analysed by varying only the value of Window Size (N) and keeping everything else constant.

Window Size (N)	Average delay (in seconds)
1	402
2	324
4	183
8	176
16	155
32	130
64	110
128	109
256	108

512	107
1024	107

Graph:



Observation: As exemplified by the graph, the average delay is consistently decreasing with increase in window size. This graph is not exactly same as in the case of Go-Back-N where after a certain value of N delay started to increase. Due to the fact that retransmissions are selective, the decrease in the average delay is continuous.

Task 2: Effect of MSS

Setup:

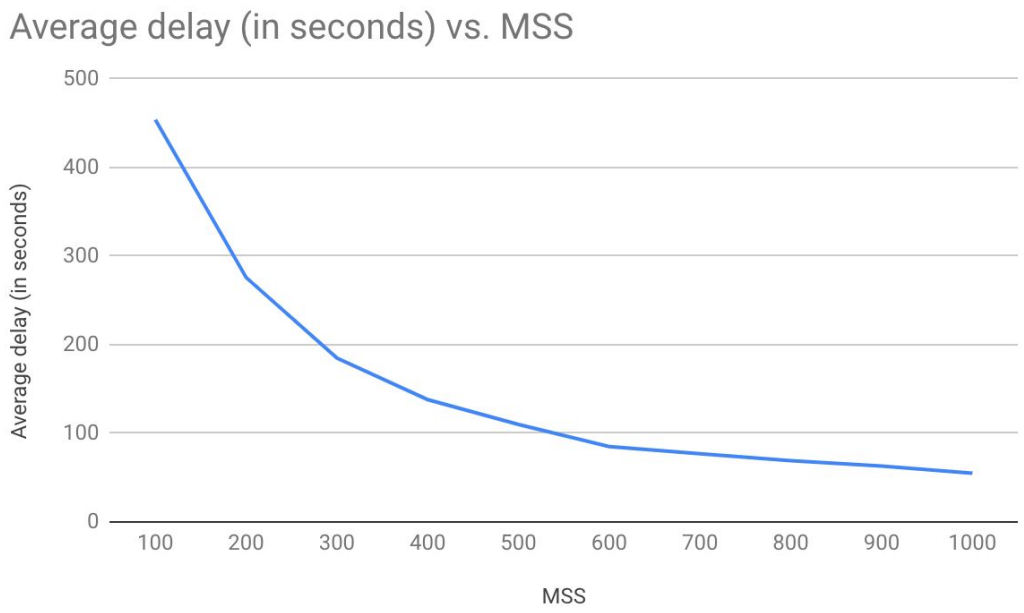
- N=64, p = 0.05, RTO = 400 ms, File Size = 1.2 MB

The value of MSS is varied from 100 bytes to 1000 bytes in increments of 100 bytes.

MSS	Average Delay (in seconds)
100	454
200	276
300	185

400	138
500	110
600	85
700	77
800	69
900	63
1000	55

Graph:



Observation: From the chart, when N=1, transfer time is the highest because client has to wait for every packet's acknowledgement before sending another packet. As N increases, the transfer time decreases because of sending/receiving many packets per Round Trip Time. Also, it is evident that for higher value of N, there is significant performance difference between Go-back-N and Selective Repeat ARQ because in Selective repeat, fewer packets need to be retransmitted.

Task 3: Effect of loss probability p

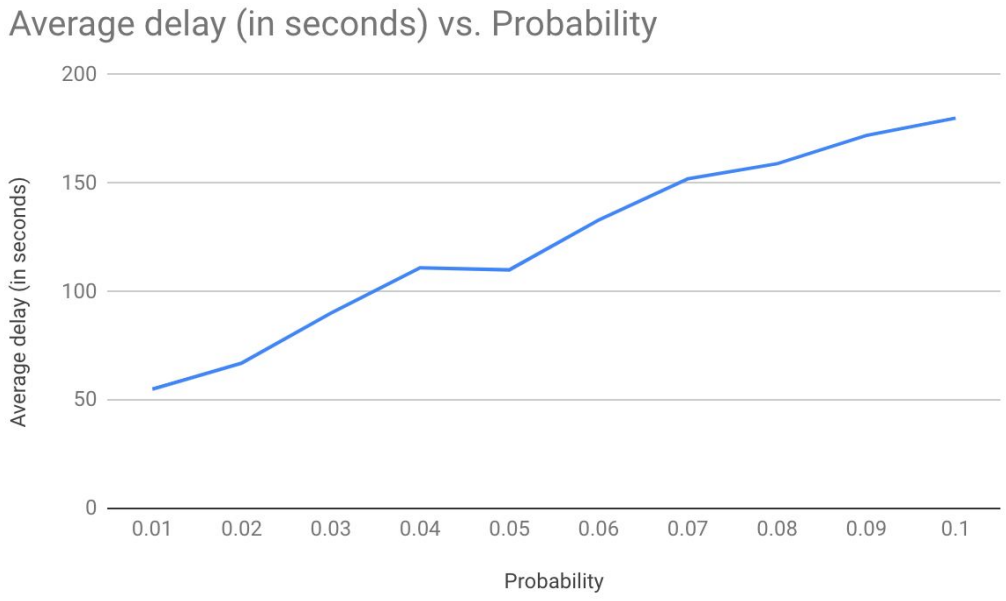
Setup:

- MSS = 500 bytes, N = 64

The loss probability is varied from 0.01 to 0.10 in increments of 0.01.

Loss probability p	Average Delay (in seconds)
0.01	55
0.02	67
0.03	90
0.04	111
0.05	110
0.06	133
0.07	152
0.08	159
0.09	172
0.10	180

Graph:



Observation: Increasing loss probability increases the average time to transfer the file because more packets need to be retransmitted due to packet loss.
